

Geochemistry of 2.7Ga shallow-facies shales in stromatolitic carbonates (ABDP #10) from Pilbara, Western Australia

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Earth's surface environments 2.7 Ga ago, by ~300Ma earlier than the inferred GOE at 2.4 Ga (e.g., Holland, 1994), likely experienced rapid continental growth and perturbation in carbon cycle. The former would have provided enhanced nutrient flux to the ocean, which facilitated primary production in the shallow ocean. In order to unravel the shallow-water environment, we obtained modern-weathering-free 2.7 Ga drilcore samples of stromatolitic carbonate and shale (Tumbiana Formation of the Fortescue Group) by Archean Biosphere Drilling Project (ABDP#10 core) in Meentheena, NE Western Australia. The purpose of this study is to extract information on the surface ocean chemistry from shallow-facies shales. Many studies exist on Tumbiana stromatolite, but few on intercalating shales.

Data on abundance and isotope compositions and organic and carbonate C, abundance and isotope compositions of five S-bearing species, abundance of Fe-bearing species, and abundance of REEs coherently suggest the following:

Active carbon recycling involved methanogenesis, and generated CH₄ was oxidized to CO₂, which was reused to form organic matter (or CH₄) by biochemical processes. CH₄ oxidation required O₂ and/or SO₄²⁻, suggesting availability of oxidized species in the 2.7 Ga shallow-water environment where positive Ce anomalies and low DOP values were often observed. Bacterial sulfate reduction would have led to pyrite formation in a "freshwater" environment, implying low sulfate concentration in a shallow-water depositional environment. Source of Fe for biogenic pyrite in the lower part of the core would have been, at least partially, sporadic and relatively low-temperature hydrothermal activity. That in the upper part of the core was dominated by continental origin. Chemical compositions of the continent 2.7 Ga ago, as the source of detrital materials, were already post-Archean-like in the course of rapid growth.